Preliminary Evaluation of Remedial Alternatives for the Subsurface Disposal Area

1. INTRODUCTION

This *Preliminary Evaluation of Remedial Alternatives* (PERA) identifies a range of potential remedial alternatives that could offer effective treatment for contaminated conditions at the Radioactive Waste Management Complex (RWMC), which has been designated as Waste Area Group (WAG) 7 at the Idaho National Engineering and Environmental Laboratory (INEEL). Evaluation in this report is limited to the Subsurface Disposal Area (SDA), which is a radioactive waste landfill at the RWMC, to support development of the WAG 7 comprehensive remedial investigation/feasibility study (RI/FS). The comprehensive RI/FS, designated as Operable Unit (OU) 7-13/14, is being conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC 9601 et seq.). Ultimately, the RI/FS will lead to risk management decisions and remediation of WAG 7, as depicted in Figure 1-1. This PERA is a precursor to the RI/FS and provides a framework for scoping the OU 7-13/14 project and completing the RI/FS.

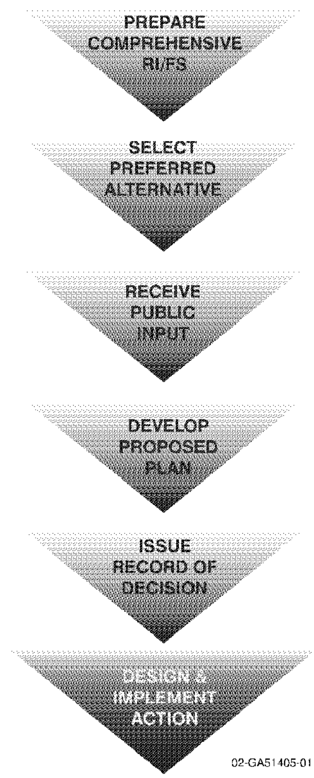

Figure 1-1. The Comprehensive Environmental Response, Compensation and Liability Act process.

The PERA follows the feasibility study organization and processes identified in the "National Oil and Hazardous Substances Pollution Contingency Plan" (40 CFR 300) and specified by CERCLA and *Guidance for Conducting RI/FS under CERCLA* (EPA 1988). Section 1 of this report summarizes site conditions, including site setting, site history, nature and extent of contamination, contaminant fate and transport, and risk estimates conducted for WAG 7. The following four subsections discuss the development and screening of remedial alternatives conducted in accordance with the CERCLA feasibility study process.

During this PERA analysis, potential remediation options are evaluated for their abilities to protect human health and the environment and meet specific regulatory requirements at WAG 7. The evaluation is based on preliminary evaluation of applicable or relevant and appropriate requirements (ARARs), remedial action objectives (RAOs), and preliminary remediation goals (PRGs). Existing, demonstrated remedial technologies and process options are compiled, listed, and evaluated for technical applicability during the initial stage of the analysis presented in Section 2. Any technology or process option that is not applicable to the SDA is removed from further consideration. The remaining remedial technologies and process options form the pool from which assembled alternatives can be developed. A preliminary set of assembled remedial alternatives is presented in Section 2. Assembled alternatives are evaluated initially in Section 3 in terms of their effectiveness, implementability, and relative cost. Though the comparative cost associated with a given alternative is a factor, the primary purpose of the initial screening step is to eliminate alternatives that cannot be implemented or do not effectively mitigate risk. Following initial screening, retained alternatives undergo detailed evaluation in Section 4, in accordance with CERCLA guidance, to address specific elements of each alternative relative to the following criteria:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost.

The remaining two CERCLA criteria, state and community acceptance, will be evaluated during development of the record of decision (ROD) for OU 7-13/14 and are not directly addressed in this analysis.

The PERA analysis culminates in Section 5 with a comparative analysis of the assembled remedial alternatives developed and evaluated in Section 4 using the identified CERCLA criteria. A schematic of the general feasibility study process adopted for this PERA, with references to specific sections of this report, is presented in Figure 1-2.

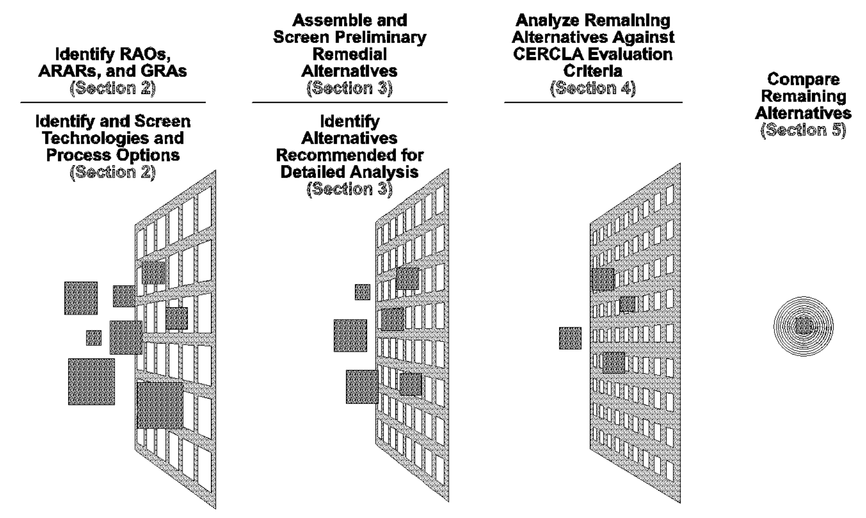

Figure 1-2. The feasibility study process.

Section 6 presents a master list of references cited in the development, screening, evaluation, and analysis of the assembled remedial alternatives. In addition, the following appendices support the analyses presented in the PERA.

- Appendix A—Applicable or Relevant and Appropriate Requirements

- Appendix B—Remedial Technologies and Process Options Identification and Screening
- Appendix C—Detailed Analysis of Alternatives
- Appendix D—Detailed Cost Estimates.

By generating a range of possible remediation approaches, referred to as general response actions (GRAs), the PERA addresses a number of potentially viable technical options for remediation of the SDA waste. Alternatives are not mutually exclusive choices, but represent a framework within which to evaluate various combinations of remedial actions that may be ultimately selected and applied to contaminated media at the SDA. While all of the alternatives (or combinations thereof) are feasible, individual evaluations provide a basis to assess relative performance according to fixed criteria and offer detailed material regarding advantages and disadvantages of each alternative.

1.1 Purpose

The purpose of the PERA is to support future development of the WAG 7 feasibility study and provide an initial assessment of remedial action alternatives for the SDA. Data developed in the PERA will provide U.S. Department of Energy Idaho Operations Office (DOE-ID), the Idaho Department of Environmental Quality (IDEQ), and the U.S. Environmental Protection Agency (EPA) with a basis for defining future OU 7-13/14 scope requirements and for supporting future risk management decisions for WAG 7 under CERCLA (42 USC 9601 et seq.) as outlined in the *Federal Facility Agreement and Consent Order* (FFA/CO) (DOE-ID 1991).

Ultimately, the evaluation of alternatives will be presented in the feasibility study and summarized in a proposed plan that will be disseminated to stakeholders to support selecting final remedial alternatives for WAG 7. A ROD will be developed to document the selected remedies. Therefore, the most critical purpose of the PERA and feasibility study is to provide sufficient information to regulatory agencies and all other stakeholders for remedial decision making.

1.2 Scope

In the decade since the FFA/CO was finalized, the signing agencies (i.e., DOE-ID, IDEQ, and EPA) have modified the scope and schedule for OU 7-13/14 because of the magnitude and duration of the project and to accommodate the scope and schedule for the OU 7-10 interim action for Pit 9 (DOE-ID 1998a, 1993, 1991; DOE 2002). The scope for the OU 7-13/14 RI/FS was outlined originally in the *Scope of Work* (Huntley and Burns 1995) and detailed in the original *Work Plan* (Becker et al. 1996). In 1997, DOE-ID, IDEQ, and EPA collaborated to prepare the *Revised Scope of Work* (LMITCO 1997) and develop the *Addendum to the Work Plan* (DOE-ID 1998b).

The primary focus of this PERA is on developing and evaluating remediation alternatives for the buried transuranic (TRU) waste received from the Rocky Flats Plant (RFP) and disposed of in the SDA from 1955 to 1970. Measures to mitigate risks associated with the remaining buried waste in the SDA are addressed for each alternative through the application of several commonly applied waste zone-specific remedial technologies. As a result, the evaluated alternatives differ only in their approaches to the RFP TRU waste. The buried waste (source term) at the SDA is defined in this PERA by the limits of the pits, trenches, soil vaults, Pad A, and impacted soil that extends to the interface with the underlying basalt layer. When evaluating short- and long-term effectiveness, the risk of each alternative is assessed, including risk associated with implementing the alternative. The assessment considers all hazardous constituents in the SDA.

The scope of the PERA is limited to evaluating alternatives that mitigate future contaminant release from the source term. Measures to address contaminants that have already been released to the environment are outside the scope of this analysis. Alternatives considered in the PERA are limited to existing, demonstrated technologies.

The success of the CERCLA process relies on managing uncertainties associated with data, technologies, and numerous other variables. Therefore, uncertainty-management principles are central considerations throughout the analysis and the design and implementation processes. Though uncertainty cannot be completely eliminated, this analysis provides a reliable basis for the future feasibility study and remedy selection by incorporating the following elements:

- Using available data on conditions and characteristics of waste sites
- Interpreting the data to adequately assess the potential range of uncertainty
- Formulating remedial alternatives to address the potential range of conditions
- Evaluating alternatives based, in part, on their ability to provide a protective remedy throughout the potential range of conditions.

Extensive site-specific information is available to support the preliminary evaluation of remedial alternatives developed in the following subsections. This information was presented in the *Ancillary Basis for Risk Analysis* (ABRA) (Holdren et al. 2002) and includes references to detailed waste inventory records, descriptions of environmental site characteristics (i.e., nature and extent of contamination) physical site properties, and estimates of risks to human health and the environment. A summary of the information is presented in the following subsections.

1.3 Background Information

The INEEL is a U.S. Department of Energy (DOE) facility that has been devoted to energy research and related activities since being established as the National Reactor Testing Station in 1949. The National Reactor Testing Station was renamed as the Idaho National Engineering Laboratory in 1974 to reflect the broad scope of engineering activities taking place at various on-Site facilities. In 1997, the Site was renamed the Idaho National Engineering and Environmental Laboratory in keeping with contemporary emphasis on environmental research. Various programs at the INEEL are conducted under the supervision of three DOE offices: (1) the DOE-ID, (2) the Pittsburgh Naval Reactors Office, and (3) the Chicago Operations Office. With overall responsibility for the INEEL, DOE-ID selects and authorizes government contractors to operate at the facility, which currently provides a variety of programmatic and support services related to nuclear reactor design and development, nonnuclear energy development, materials testing and evaluation, operational safety, radioactive waste management, and environmental restoration.

The INEEL has a number of distinct and geographically separate functional facility areas, which serve or have served a particular programmatic or support activity. These areas have been designated as WAGs as a result of the INEEL being placed on the National Priorities List in 1989. The RWMC is a solid radioactive waste storage and disposal site located in the southwest portion of the INEEL. Waste Area Group 7 is the designation in the FFA/CO for the collective facilities within the perimeter fence at the RWMC, which include the SDA, the Transuranic Storage Area (TSA), and the adjacent administration and operations areas. The general layout of the RWMC is shown in Figure 1-3.

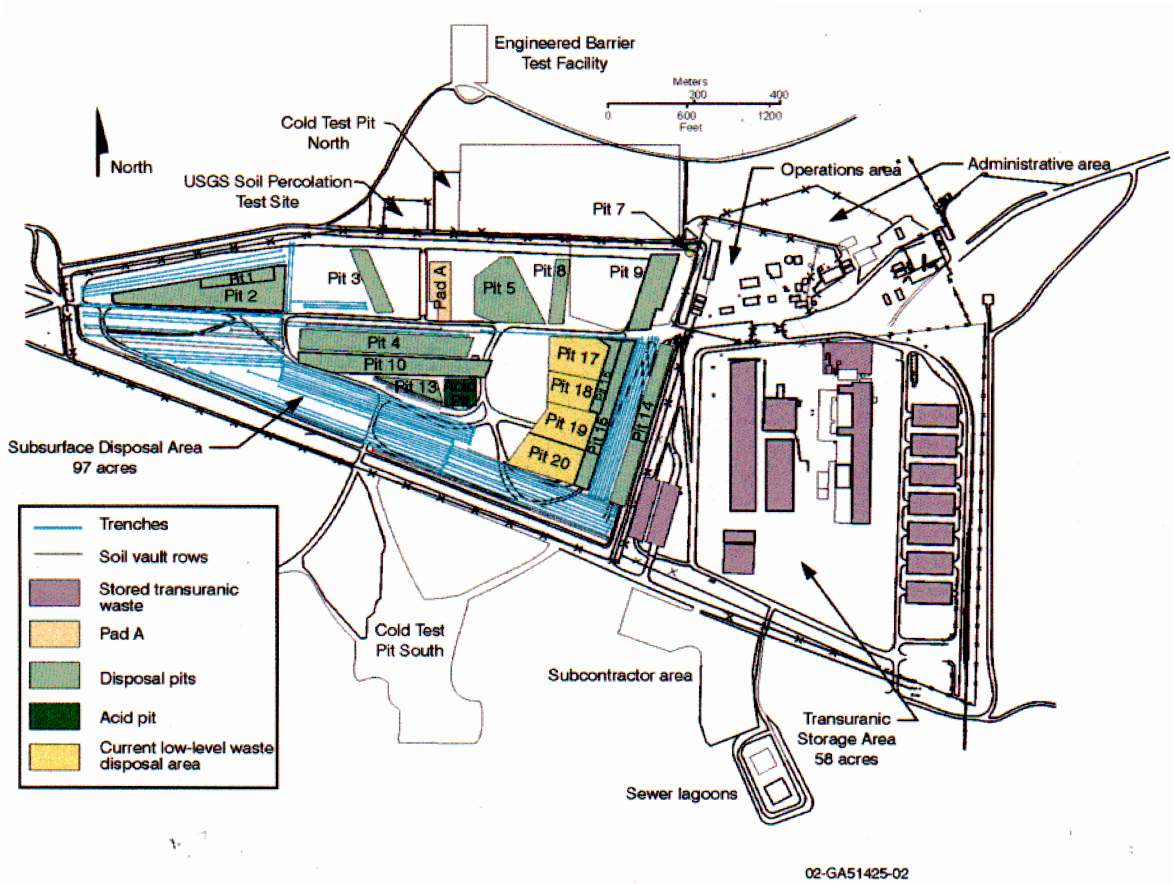

Figure 1-3. Physical layout of the Radioactive Waste Management Complex.

1.3.1 Site Description

The INEEL is located in southeastern Idaho and occupies 2,305 km^2 (890 mi^2) in the northeastern region of the Snake River Plain. Regionally, the INEEL is nearest to the cities of Idaho Falls and Pocatello and to U.S. Interstate Highways I-15 and I-86. The INEEL extends nearly 63 km (39 mi) from north to south, is about 58 km (36 mi) wide in its broadest southern portion, and occupies parts of five southeast Idaho counties. The Experimental Breeder Reactor I, which is a national historic landmark, and public highways (i.e., U.S. 20 and 26 and Idaho 22, 28, and 33) within the INEEL boundary are accessible without restriction. Otherwise, access to the INEEL is controlled. Neighboring lands are used primarily for farming or grazing or are in the public domain (e.g., national forests and state-owned land). The location and general layout of the INEEL facility are shown in Figure 1-4.

1.3.1.1 Physiography. The INEEL is located in the Eastern Snake River Plain, (ESRP). The ESRP is the largest continuous physiographic feature in southern Idaho. This large topographic depression extends from the Oregon border across Idaho to Yellowstone National Park and northwestern Wyoming. The INEEL is located on the northern side of the ESRP and adjoins the Lost River, Lemhi, and Beaverhead mountain ranges to the northwest (see Figure 1-4), which comprise the northern boundary of the plain.

The surface of the INEEL is a relatively flat, semiarid sagebrush desert with an average rainfall of 22.1 cm/year (8.7 in./year). Predominant relief is manifested either as volcanic buttes jutting up from the desert floor or as unevenly surfaced basalt flows or flow vents and fissures. Elevations at the INEEL range from 1,460 m (4,790 ft) in the south to 1,802 m (5,913 ft) in the northeast.

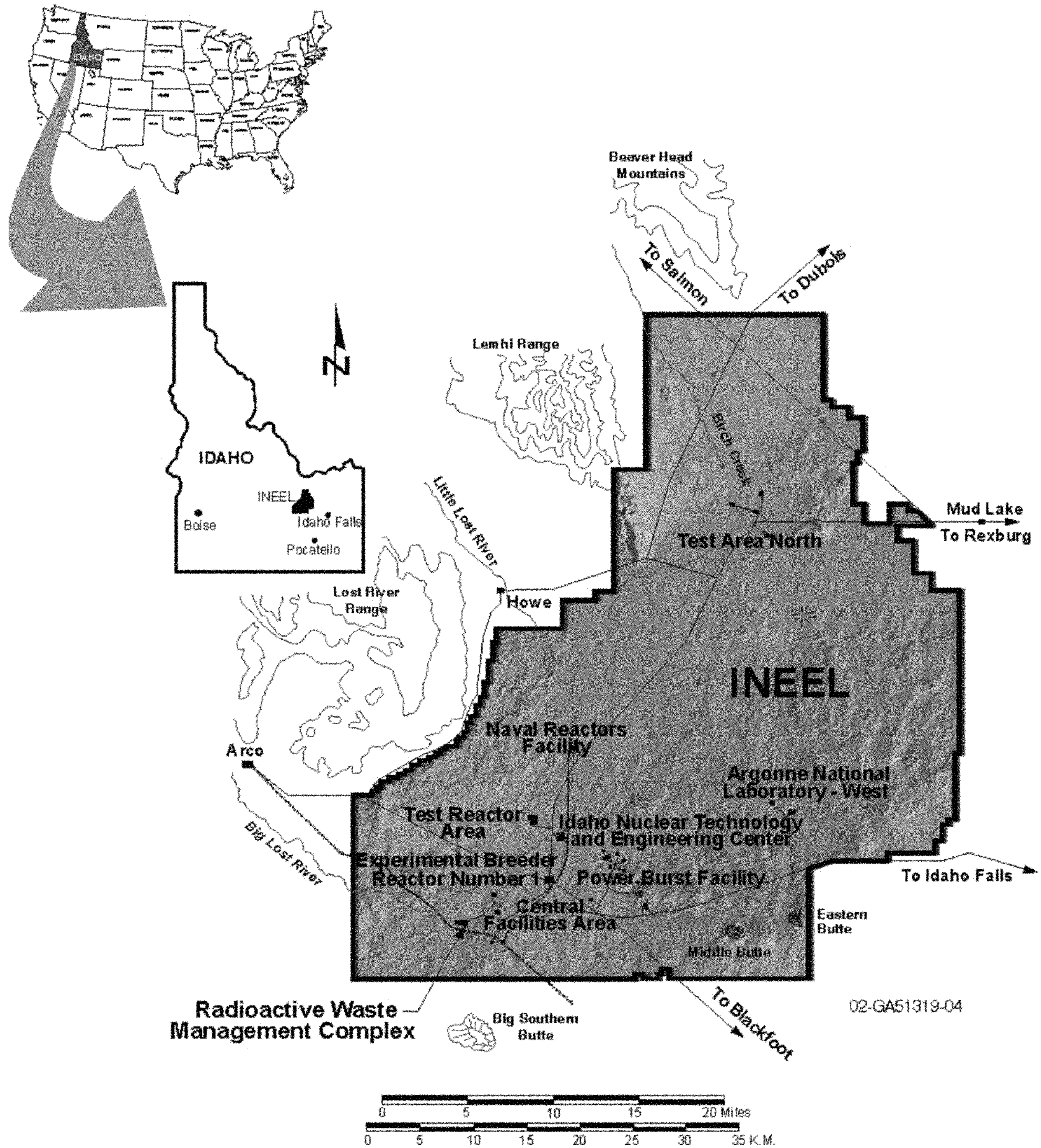

Figure 1-4. Relief map of the Idaho National Engineering and Environmental Laboratory.

The RWMC is located in the southwest portion of the INEEL, southeast of the diversion dam on the Big Lost River and east and northeast of the flood control spreading areas. The RWMC lies within a topographic depression circumscribed by basaltic ridges. Local elevations range from a low of 1,517.3 m (4,978 ft) to a high of 1,544.7 m (5,068 ft).

1.3.1.2 Surface and Subsurface Geology. The surface of the INEEL is covered generally by Pleistocene and Holocene basalt flows ranging in age from 300,000 to 3 million years (Hackett, Pelton, and Brockway 1986). Regional subsurface conditions consist mostly of layered basalt flows with a few comparatively thin layers of sedimentary deposits. Layers of sediment, referred to as interbeds, tend to retard infiltration to the aquifer and are important features in assessing the fate and transport of contaminants.

Undisturbed surficial sediments at the RWMC range in thickness from 0.6 to 7.0 m (2 to 23 ft) and consist primarily of fine-grained playa and alluvial material (Kuntz et al. 1994). The near surface basalt flows erupted from several volcanic vents in the southwestern part of the INEEL. Anderson and Lewis (1989) defined 10 basalt flow groups and seven major sedimentary interbeds in the area. The interbeds generally consist of unconsolidated sediments, cinders, and breccia. In the 177-m (580-ft) interval from the ground surface to the aquifer, three major interbeds are of particular importance. Using nomenclature established by the U.S. Geological Survey, these sedimentary layers are referred to as the A-B, B-C, and C-D interbeds, so named for the basalt flow groups (i.e., A, B, C, and D) that bound the layers above and below. The three uppermost sedimentary layers also are commonly referred to as the 30-, 110-, and 240-ft interbeds. The C-D interbed is by far the most continuous. However, each of the interbeds contains known gaps. The A-B interbed is very discontinuous and generally exists only beneath the northern half of the SDA.

1.3.1.3 Subsurface Hydrology. The crescent-shaped Snake River Plain Aquifer (SRPA) underlies the eastern portion of the ESRP. The aquifer is bounded on the north and south by the edge of the Snake River Plain; on the west by the surface discharge into the Snake River near Twin Falls, Idaho; and on the northeast by the Yellowstone basin. Consisting of a series of water-saturated basalt layers and sediment, the aquifer underlies the RWMC at an approximate depth of 177 m (580 ft) and flows generally from the northeast to the southwest. In the following paragraphs, the subsurface hydrology at the INEEL is discussed as three components: (1) vadose zone, (2) perched water, and (3) the SRPA.

The vadose zone is defined as the unsaturated zone between land surface and water table. Vadose zone thickness near the RWMC is approximately 180 to 186 m (590 to 610 ft). Rates of moisture movement in sediment and basalt under varying moisture conditions have been quantified near WAG 7. These quantified rates vary widely and depend on the location, material type, and timing of infiltration at the surface. Studies by Hubbell (1992) suggested that water moved from the surface to a depth of 221 ft in less than 5 years (12 m/year or 40 ft/year). Bishop (1996) reported a wide variation in net drainage from surficial sediments into underlying basalt, which ranged from a high of 49.4 cm/year (19.5 in./year) to less than 0.3 cm/year (0.1 in./year). A moisture movement rate of 5 m/day (16 ft/day) was measured from land surface to a depth of 55 m (180 ft) through the fractured basalt medium during an aquifer pumping and infiltration test conducted in the summer of 1994 (Porro and Bishop 1995) approximately 2.1 km (1.3 mi) south of the RWMC.

Perched water at the INEEL forms when a layer of dense basalt or fine sedimentary material occurs with a hydraulic conductivity that is sufficiently low so that downward movement of infiltrating water is restricted. Perched water is transitory beneath the RWMC, but has been detected in 11 boreholes at various times. Typically, the perched water wells are dry or contain so little water that the volume collected for analysis is limited. Perched water bodies have been identified at two depth intervals at WAG 7, at depths of approximately 24 to 27 m (80 to 90 ft) and 61 to 67 m (200 to 210 ft), corresponding to the B-C and C-D interbeds, respectively. Perched water typically occurs in fractured basalt above the interbeds.

The SRPA is defined as the saturated portion of a series of basalt flows and interlayered pyroclastic and sedimentary materials that underlie the ESRP. The SRPA arcs approximately 354 km (220 mi) through the eastern Idaho subsurface and varies in width from approximately 80 to 113 km (50 to 70 mi). Total area of the SRPA is estimated at 24,862 km^2 (9,600 mi^2). The SRPA is recharged primarily by infiltration from rain and snowfall that occur within the drainage basin surrounding the ESRP and from deep percolation of irrigation water. Water is pumped from the aquifer primarily for human consumption and irrigation (Irving 1993). In the vicinity of the RWMC, the SRPA lies approximately 180 to 197 m (590 to 610 ft) below land surface (Wood and Wylie 1991). Regional groundwater flow is to the south-southwest; however, the flow direction can be affected locally by recharge from rivers, surface water spreading areas, and heterogeneities in the aquifer. Local groundwater flow direction is north-northeast to south-southwest; however, the water-level map for the RWMC indicates a relatively flat groundwater gradient across the site. Flow velocities within the SRPA range from between 1.5 to 6.1 m/day (5 to 20 ft/day) (Irving 1993).

1.3.1.4 Surface Hydrology. Most of the INEEL is located in the Pioneer Basin into which three streams drain: (1) the Big Lost River, (2) the Little Lost River, and (3) Birch Creek. These streams receive water from mountain watersheds located to the north and northwest of the INEEL. Stream flows often are depleted before reaching the facility by irrigation diversions and infiltration losses along stream channels. The Pioneer Basin has no outlet; thus, when water flows onto the INEEL, it either evaporates or infiltrates into the ground (Irving 1993). The general surface water features of the site are depicted in Figure 1-5.

The Big Lost River is the major surface water feature on the INEEL. Its waters are impounded and regulated by the Mackay Dam, which is located approximately 6 km (4 mi) north of Mackay, Idaho. Flow in the Big Lost River that actually reaches the facility is either diverted at the INEEL diversion dam to spreading areas southwest of the RWMC or flows northward across the INEEL in a shallow channel to its terminus at the Lost River Sinks, at which point, the flow is lost to evaporation and infiltration (Irving 1993).

The RWMC is located within a natural topographic depression with no permanent surface water features. However, the local depression tends to hold precipitation and to collect additional run-off from the surrounding slopes. Surface water either eventually evaporates or infiltrates into the vadose zone (i.e., the unsaturated subsurface) and underlying aquifer. As discussed by Keck (1995), the Big Lost River is not a surface water flow path for contaminant transport at the SDA.

Historically, the SDA has been flooded by local run-off at least three times because of a combination of snowmelt, rain, and warm winds. Dikes and drainage channels were constructed around the perimeter of the SDA in 1962 in response to the first flooding event. Height of the dike was increased and the drainage channel was enlarged, following a second flood in 1969. The dike was breached by accumulated snowmelt in 1982, resulting in a third inundation of the SDA. Significant flood-control improvements were subsequently implemented, which included increasing height and width of the dike, deepening and widening the drainage channel, and surface contouring to eliminate formation of surface ponds within the SDA.

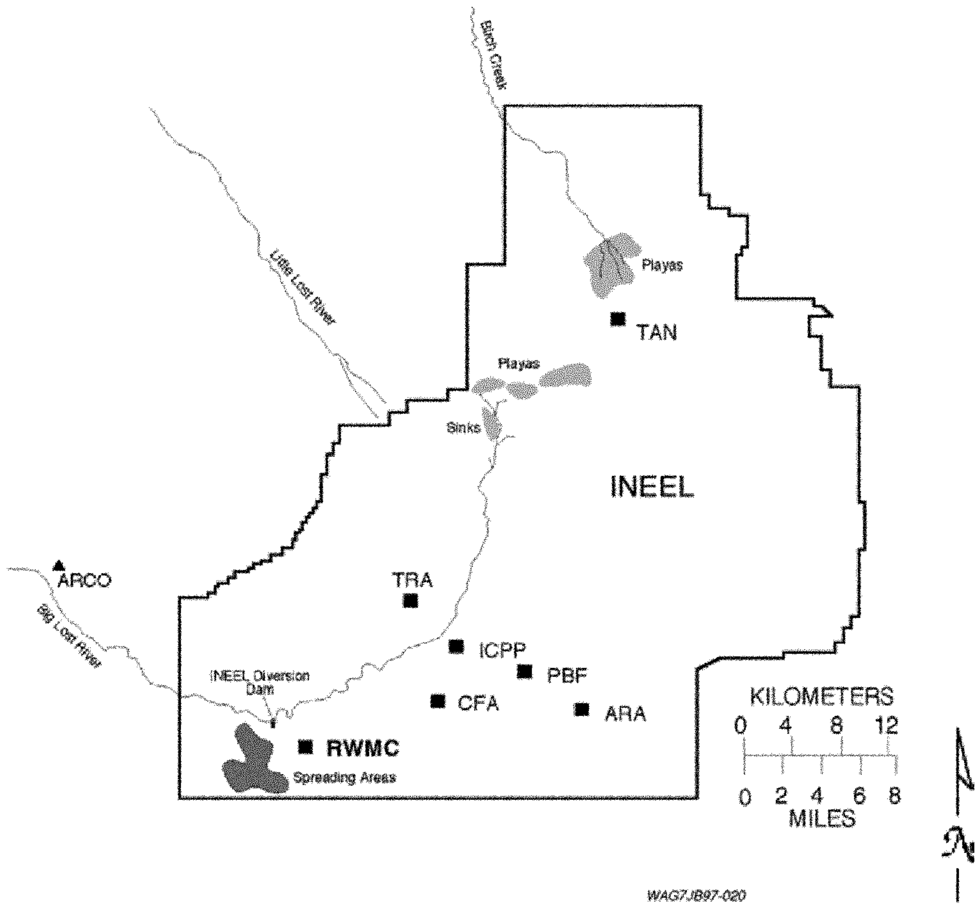

Figure 1-5. Surface water features.

1.3.1.5 Seismic Activity. Seismic activity of eastern Idaho is concentrated along the Intermountain Seismic Belt, which extends more than 1,287 km (800 mi) from southern Arizona through eastern Idaho to western Montana. The RWMC is subject to the same seismic influences. The Idaho Seismic Zone extends westward along the Idaho Seismic Belt from the Yellowstone Plateau area into central Idaho. Though several large magnitude earthquakes have occurred in mountain ranges surrounding the INEEL, earthquakes beneath the Eastern Snake River Plain are rare and have small magnitudes (Jackson et al. 1993). Minor earthquakes have occurred east and north of the INEEL with an average local magnitude of 1.0 on the Richter scale.

1.3.1.6 Volcanic Hazards. The INEEL is located in a region of Pleistocene and Holocene volcanic activity, typically characterized by nonviolent, effusive basalt lava flows (Hackett and Smith 1992). Four to 7 million years ago, explosive rhyolite volcanism occurred beneath the INEEL, forming calderas now buried beneath basalt lava flows. The most recent lava flows within the INEEL boundary occurred 13,000 years ago near the southern boundary—the Cerro Grande flow (Hackett, Pelton, and Brockway 1986). Past patterns of volcanism suggest that future volcanism at the INEEL within the next 1,000 to 10,000 years is very improbable (EG&G 1990). Furthermore, the Volcanism Working Group (EG&G 1990) estimated the probability of RWMC inundation by basalt flow to be less than 1E-05 per year. Even with this unlikely event, the principal effect on the surficial and buried waste would be localized heating to 300°C (572°F) to a depth of less than 3 m (9.8 ft). Other potential effects (i.e., fissuring and gas corrosion) are even more unlikely because the RWMC lies outside known volcanic rift zones (Hackett, Anders, and Walter 1994).

1.3.1.7 Demography. Populations potentially affected by INEEL activities include employees, ranchers who graze livestock in areas on or near the INEEL, hunters, residential populations in neighboring communities, highway traffic along U.S. Highway 20/20, and visitor traffic at the Experimental Breeder Reactor No. 1. Nine separate facilities at the INEEL include a total of approximately 450 buildings and more than 2,000 other support facilities. As of December 2001, the on-Site workforce was estimated at 3,653 employees, including 308 at the RWMC. Authorized groups are occasionally escorted at the RWMC. Subcontract employees and personnel from IDEQ and EPA oversight programs also visit the area.

The nearest community to the INEEL is Atomic City, located south of the site border on U.S. Highway 20/26. Other population centers near the INEEL include Arco, 11 km (7 mi) to the west; Howe, located to the west on U.S. Highway 22/33; and Mud Lake and Terreton on the northeast border. The INEEL has no permanent residents (Hull 1989).

1.3.1.8 Flora and Fauna. The INEEL site serves as a refuge for wildlife habitat. The central core of the site may constitute the largest area of undeveloped and ungrazed sagebrush steppe outside of the national park lands in the Intermountain West. Because the INEEL is located at the mouth of several mountain valleys, large numbers of migratory birds of prey and mammals are funneled into the region. More than 290 vertebrate species—including 45 mammals, 225 birds, 12 reptiles, and 6 fish—have been observed within the INEEL boundaries. Nearly all the avian and mammalian species found across the INEEL could occur in the WAG 7 area. Avian species include game birds, such as sage grouse, and various raptor species. Burrowing rodents (such as ground squirrels and mice) and insects (such as harvester ants) are of particular interest given buried waste conditions at the SDA. Larger mammalian species, such as coyote and antelope, also are present.

Six broad vegetation categories representing nearly 20 distinct habitats have been identified on the INEEL. Nearly 90% of the area is covered by shrub-steppe vegetation, which is dominated by big sagebrush, saltbush, rabbitbrush, and native grasses (DOE-ID 2001). Small riparian and wetland regions also exist along the Big Lost River and Birch Creek.

1.3.1.9 Cultural Resources. Undisturbed sagebrush rangelands and developed facilities found on the INEEL contain sensitive cultural resources reflecting human use of the region for a period in excess of 12,000 years. Ten major archaeological survey projects have identified an inventory of 13 potentially significant prehistoric sites with a 200-m (656-ft) -wide zone surrounding the fenced perimeter of the RWMC and more than 80 additional archaeological resources in the surrounding area. In addition, paleontological remains have been identified in excavations within the facility. Finally, architectural surveys of the DOE-ID administered buildings within the developed portion of the RWMC have identified three buildings that may be eligible for nomination to the National Register.

1.3.1.10 Land Use. The land within the INEEL is administered by DOE and is classified by the Bureau of Land Management as industrial and mixed-use acreage (DOE-ID 2001). The current primary use of INEEL land is to support facility and program objectives. Large tracts of land are reserved as buffer and safety zones around the boundary of the INEEL, while portions within the central area are reserved for INEEL operations. The remaining land within the core of the reservation, which is largely undeveloped, is used for environmental research and to preserve ecological and cultural resources. The U.S. Government owns most of the land immediately adjacent to the INEEL. The perimeter buffer consists of 1,295 km^2 (500 mi^2) of grazing land (DOE-ID 2001) administered by the Bureau of Land Management. In the surrounding counties, approximately 45% of the land is used for agriculture, 45% is undeveloped land, and 10% is urban (DOE-ID 2001).

Land use at the RWMC is limited to industrial applications with present waste management operations and associated expansion expected to continue. The TSA, which is contained within a security fence, is dedicated to the temporary storage of contact- and remote-handled solid TRU waste. The TSA also contains the Advanced Mixed Waste Treatment Project (AMWTP), which is currently under construction. Operations at the AMWTP complex are scheduled to begin in 2003 with the major mission to retrieve and treat 65,000 m^3 of INEEL low-level and TRU waste currently stored at the TSA.

Future land use is addressed in the *Long-Term Stewardship Land Use Future Scenarios for the Idaho National Engineering Laboratory* (DOE-ID 1995), the *Idaho National Engineering and Environmental Laboratory Comprehensive Facility and Land Use Plan* (DOE-ID 2001), and the *Infrastructure Long-Range Plan* (INEEL 2001). The Long-Term Stewardship Initiative will encompass all future activities, including physical and institutional controls, monitoring and surveillance, and other steps necessary to protect human health and the environment from hazards remaining at the INEEL after selected cleanup strategies are compete. Future land use most likely will remain essentially the same as the current use—a research facility within the INEEL boundaries with adjacent areas consisting of primarily agricultural and undeveloped land.

1.3.2 Site History

The RWMC, located in the southwestern quadrant of the INEEL, encompasses a total of 72 ha (177 acres) and is divided into three separate areas by function: (1) the SDA, (2) the TSA, and (3) the administration and operations area. The original landfill, established in 1952, covered 5.2 ha (13 acres) and was used for shallow land disposal of solid radioactive waste. In 1958, the landfill was expanded to 35.6 ha (88 acres). Relocation of the security fence in 1988 to outside the dike surrounding the landfill established the current size of the SDA as 39 ha (97 acres). The TSA was added to the RWMC in 1970. Located adjacent to the east side of the SDA, the TSA encompasses 23 ha (58 acres) and is used to store, prepare, and ship retrievable TRU waste to the Waste Isolation Pilot Plant (WIPP). The 9-ha (22-acre) administration and operations area at the RWMC includes administrative offices, maintenance buildings, equipment storage, and miscellaneous support facilities.

The SDA is a radioactive waste landfill with shallow subsurface disposal units consisting of pits, trenches, and soil vaults. Contaminants in the landfill include hazardous chemicals, remote-handled fission and activation products, and TRU radionuclides. Waste acceptance criteria and record-keeping protocols for the facility have changed over time in keeping with waste management technology and legal requirements. Today's requirements are much more stringent as a result of knowledge developed over the past several decades about potential environmental impacts of waste management techniques. Previously, however, shallow landfill disposal of radioactive and hazardous waste was the technology of choice. The general layout of the SDA, showing relative locations of individual disposal units, is presented in Figure 1-6.

At the SDA, disposals of TRU and mixed waste—mostly from RFP in Colorado—were allowed through 1970. Buried RFP TRU waste, located primarily in Pits 2 through 6 and 9 through 12, and Trenches 1 through 10, is depicted in Figure 1-6. Disposal of mixed waste containing hazardous chemical and radioactive contaminants was allowed through 1984. Since 1985, waste disposals in the SDA have been limited to low-level radioactive waste generated at the INEEL. Construction, operation, and decommissioning of the INEEL nuclear reactor testing programs have resulted in large volumes of waste. Various containers were used in shipping and disposing of the waste, including steel drums (30-, 40-, and 55-gal), cardboard cartons, and wooden boxes (as large as 105 × 105 × 214 in.). Larger individual items—such as tanks, furniture, process and laboratory equipment, engines, and vehicles—were placed separately as loose trash.

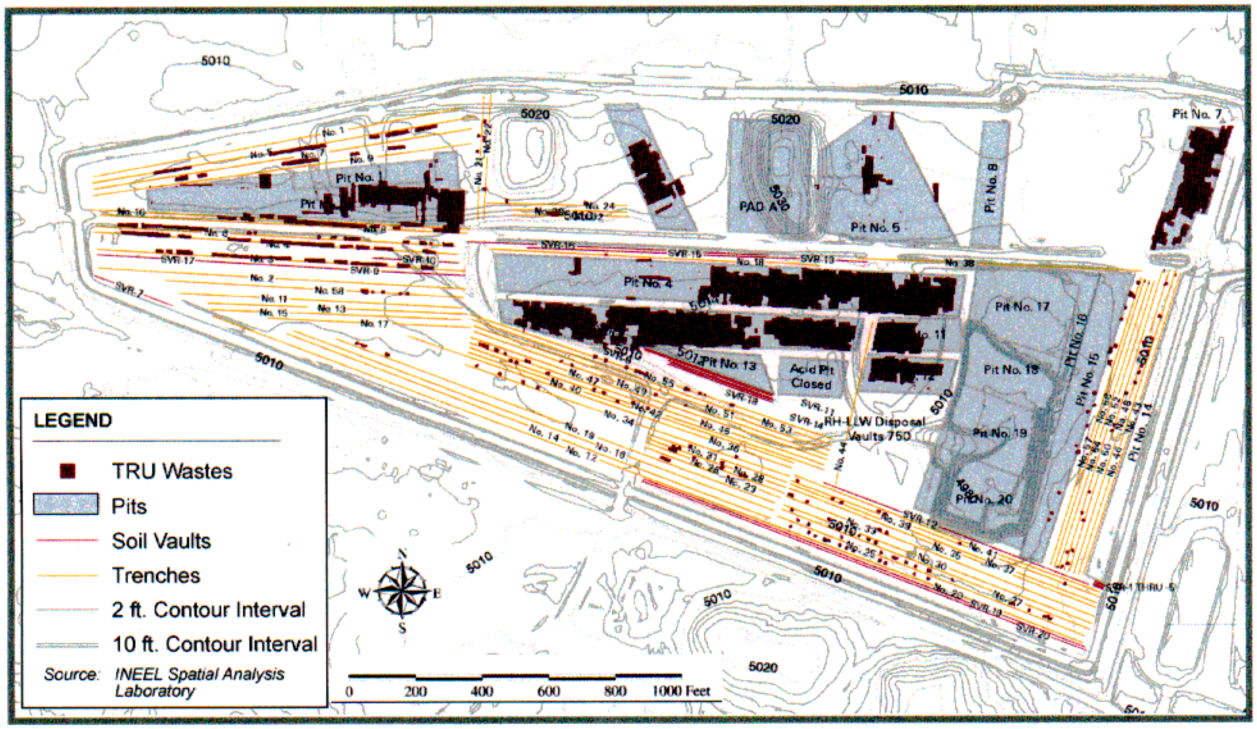

Figure 1-6. Subsurface Disposal Area waste disposal units.

Radioactive waste from off-Site sources originated from a variety of facilities, including military and other defense agencies, universities, commercial operations, and the Atomic Energy Commission. The primary off-Site contributor was the RFP, which shipped TRU waste to the SDA between 1954 and 1970. The three primary RFP facilities that generated the radioactive waste were the Aqueous Waste Treatment Facility, the Plutonium Recovery Facility, and the Plutonium Production Facility.

- The Aqueous Treatment Facility treated process waste and other liquid plant waste. Facility waste included several types of sludge and evaporation salt.
- The Plutonium Recovery Facility recovered plutonium from various weapon-production operations using a variety of methods, including incineration, leaching, and ion exchange. The waste produced included glass, combustibles, sand, slag, crucible heels, and process equipment.
- The Plutonium Production Facility produced waste during routine operations, which included combustibles, graphite molds, metals, filters, and glass. Additional waste includes that generated in the 1969 fire that contained foundry and production equipment (e.g., gloveboxes, presses, lathes, furnaces, rolling mills, filters, piping, masonry brick, ducting, and some structural elements).

Between 1954 and 1960, waste shipments from RFP were disposed of in Trenches 1 through 15, interspersing TRU waste with low-level waste (LLW) generated at the INEEL. In 1957, the use of pits for RFP waste was instituted. Initially, waste was stacked in pits and trenches. However, beginning in 1963, waste was simply dumped to reduce labor costs and minimize personal radiation exposures.

1.3.2.1 Disposal Units. Waste in the SDA is buried in pits, trenches, soil vaults, and on an abovegrade pad. A brief description of individual burial sites, along with a discussion of associated waste disposal practices, is presented in the following paragraphs. Conceptual cross-sectional views depicting the types of individual waste units within the SDA are presented in Figure 1-7.

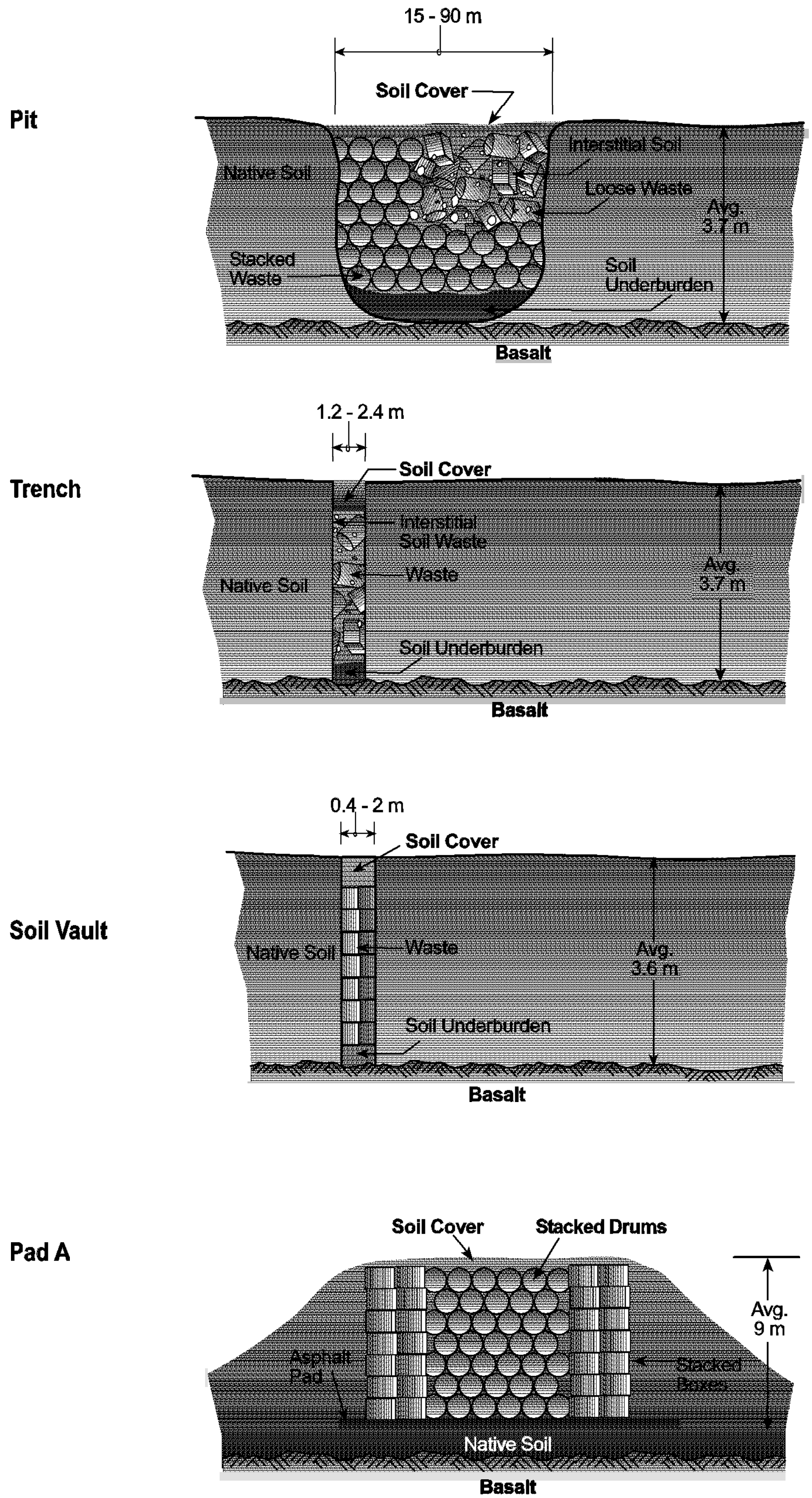

Figure 1-7. Generic cross section of pits, trenches, soil vaults, and Pad A.

1.3.2.1.1 Pits—A total of 16 pits were opened, filled, and closed (covered with soil) in the SDA between 1957 and 1984. Pits contain TRU, mixed TRU, mixed low-level waste (MLLW), and LLW—primarily in drums, cardboard boxes, and garbage cans. Many shipments were not in containers and included trucks, tanks, and miscellaneous debris. Drums disposed of in Pits 1, 2, and 3 were stacked from 1957 until 1963. Drums were randomly dumped in Pits 4 through 9 from 1960 to 1969. Pits 1 through 6 and 9 through 12 received TRU waste from RFP, while the remaining pits generally received non-RFP waste. Detailed information regarding the waste is presented in the ABRA (Holdren et al. 2002).

The pits were excavated to various sizes. Dimensions ranged from approximately 15 to 90 m (50 to 300 ft) wide and 75 to 335 m (250 to 1,100 ft) long, averaging approximately 3.7 m (12 ft) deep. In general, pits were excavated to the underlying basalt layer. Beginning in 1970, a minimum of 0.6 m (2 ft) of soil was placed over the exposed basalt before placement of the waste. After waste was emplaced, pits were backfilled and covered with about 1 m (3 ft) of soil (Vigil 1988).

Pits 17 through 20 comprise a single, large, excavated area currently used for LLW disposal. Pits 16 and 17 are closed, and the boxes on the west side of the pits have been covered with soil to shield workers. Waste is stacked in pits using forklifts and cranes. Concrete vaults, used for remote-handled LLW, are located in the southwest corner of Pit 20.

1.3.2.1.2 Trenches—Trenches within the SDA have various lengths, up to approximately 304 m (1,000 ft) long. They are on average 1.2 to 2.4 m (5 to 8 ft) wide and 3.7 m (12 ft) deep (Vigil 1988). Trenches 1 through 10 received waste from 1952 until 1957 (Vigil 1988), though shipments from RFP did not begin until 1954. Trenches 11 through 15 received waste from RFP in 1958 and 1959, and minor amounts of RFP waste was place in Trenches 19 and 32. These early trenches received cardboard boxes, wooden boxes, and garbage cans containing mixed fission products and drums and wooden crates containing TRU waste. Trenches 11 through 58 were opened, filled, and closed (covered with soil) from 1958 through 1981 and generally contain drums, boxes, and loose material.

General disposal practices were the same for pits and trenches. Waste was compacted and bailed; larger bulky items were wrapped in plastic; and smaller, noncompactible waste was contained in wooden boxes and covered with fire-retardant paint (Becker et al. 1998). Some waste was disposed of in shielded casks to reduce radiation exposure rates.

1.3.2.1.3 Soil Vault Rows—Beginning in 1977, soil vault rows (SVRs) were constructed to dispose of remote-handled, high-radiation LLW (defined as material producing a beta-gamma exposure rate of greater than 500 mR/hr at a distance of 0.9 m [3 ft]). Individual soil vaults are unlined, cylindrical vertical-augured shafts with diameters up to 2 m (6.7 ft) and depths averaging 3.6 m (11.8 ft). Soil Vault Rows 1 to 21 have been closed and covered with soil. Each vault is separated from previously buried waste by approximately 0.6 m (2 ft).

1.3.2.1.4 Pad A—Formerly known as the Engineered Waste Storage Area or the Transuranic Disposal Area, Pad A was constructed in 1972. An asphalt pad was built on the ground surface in an area that was unsuitable for subsurface disposal because of near-surface basalt outcroppings. Pad A received waste from 1972 to 1978. Pad A contains TRU alpha-emitting radioisotopes with concentrations less than 10 nCi/g and radiation levels less than 200 mR/hr at the container's surface. Two shipments contained TRU waste at concentrations greater than 100 nCi/g (Halford et al. 1993). Waste drums and plywood boxes were stacked and covered with soil. Each stack at Pad A consisted of as many as 11 drums or 5 boxes—drums were stacked horizontally in staggered layers, and boxes were stacked around the periphery of the pad. The overall dimensions of Pad A are 73 m (240 ft) by 102 m (335 ft).

When Pad A was closed in 1978, waste containers occupied only the eastern half of the pad. During closure activities, exposed waste containers were covered with plywood, polyethylene, and a final soil cover, which consisted of a 1-m (3.3-ft) top cover and side berms having a maximum slope of 3 horizontal to 1 vertical (3H:1V) (LMITCO 1995).

1.3.2.2 Waste Retrieval Activities. The Initial Drum Retrieval Project at the SDA was performed to demonstrate safe retrieval of drums and gain experience in handling and repackaging drums for interim storage. Retrieval operations began in 1974 and were completed in June 1978. Retrieval was limited to Pits 11 and 12 and resulted in retrieval of 20,262 drums with a TRU waste volume of 4,391 m^3 (5,743 yd^3) (McKinley and McKinney 1978).

Another waste retrieval operation, the Early Waste Retrieval Project, was initiated in 1976 to develop methods and equipment for safely retrieving TRU waste that had been buried for 22 to 24 years. The operation, which terminated in 1978, retrieved a total of 170.6 m^3 (223.1 yd^3) of waste from Pits 1 and 2 and Trenches 5, 7, 8, 9, and 10. Retrieved waste included 457 drums, 34.3 m^3 (44.9 yd^3) of loose waste, and 24.3 m^3 (31.8 yd^3) of contaminated soil. All waste was wrapped in plastic before repackaging and placed in drums and steel bins for interim storage in the TSA. All equipment was decontaminated, and excavations were backfilled following completion of retrieval operations.

At the time of this report, plans were in place to retrieve waste from a portion of Pit 9. Retrieval operations were scheduled to begin in 2003 and were designed to demonstrate specific retrieval and material-handling technologies.

1.3.3 Nature and Extent of Contamination

The nature and extent of contamination associated with the SDA in all environmental media were evaluated in the ABRA (Holdren et al. 2002). Human health contaminant screening in the *Interim Risk Assessment* (IRA) (Becker et al. 1998) and the ecological contaminant screening in the *Review of Waste Area Group 7 Ecological Contaminants of Potential Concern* (Hampton and Becker 2000) document was used in the ABRA (Holdren et al. 2002) to define contaminants for analysis. The human health contaminants of potential concern included 20 radionuclides and four chemical contaminants. Many of these contaminants also were identified as ecological contaminants of potential concern.

In addition to routine monitoring at the RWMC, several unique approaches have been adopted to characterize the nature and extent of contamination. A database containing contaminant inventories and waste descriptions was developed to describe the waste zones. A second database was created to map characterization data and disposal locations in the SDA. The mapping software, WasteOScope, is based on historical disposal records, including RFP shipping manifests and trailer load lists. In addition, electromagnetic and soil gas surveys were evaluated against waste zone maps. More than 300 probes were installed to characterize buried waste using instruments developed at the INEEL. Data from surveys and probes were incorporated into WasteOScope to allow visually superimposing various data sets. A new type of tensiometer, referred to as the advanced tensiometer, also was developed at the INEEL to allow deeper tensiometer monitoring in the vadose zone.

The evaluation of nature and extent considered depth intervals as follows: waste zone, interval excluding waste zone and extending from the surface to 11 m (35 ft), from 11 to 43 m (35 to 140 ft), from 43 to 77 m (140 to 250 ft), and depths greater than 77 m (250 ft). These intervals were defined to reflect regions bounded by the A-B, B-C, and C-D interbeds.

Contaminants of potential concern have been detected at low concentrations in the vadose zone and may be migrating toward the aquifer. Most vadose zone detections are in the 0- to 11-m (0- to 35-ft) and

11- to 43-m (35- to 140-ft) intervals above the B-C interbed, with some contaminants detected in deeper intervals. The most frequently detected contaminants in the environment include nitrates, carbon tetrachloride, C-14, Tc-99, and uranium isotopes. Other contaminants including Am-241, I-129, Pu-238, and Pu-239/240 have been detected sporadically at concentrations near detection limits. Carbon tetrachloride has been detected down to the aquifer, though concentrations decrease significantly below the B-C interbed and again below the C-D interbed. Because carbon tetrachloride migrates in the gaseous phase, it also has been detected hundreds of meters laterally away from buried waste.

A conclusion from the ABRA (Holdren et al. 2002) is that low concentrations of carbon tetrachloride, nitrates, and C-14 have been detected in the SRPA near the SDA. Carbon tetrachloride has been measured slightly above the maximum contaminant level. Low concentrations of nitrate and C-14, well below maximum contaminant levels, also have been detected in the region and may be increasing. The SDA is the obvious source of the carbon tetrachloride, but the source of the nitrate and C-14 is not as clear.

Monitoring at the RWMC has been greatly expanded since 1998 with 22 additional vadose zone lysimeters, four upgradient aquifer wells, an aquifer well inside the SDA, and more than 300 probes in the buried waste. Most of these new installations have not been operational long enough to provide substantial quantities of data. The expanded network will continue to produce data for continued evaluation of source release into the vadose zone, contaminant migration through the vadose zone, and potential impacts to the aquifer beneath the SDA. Monitoring data also will support future remediation by providing a baseline for remediation goals.

1.3.4 Contaminant Fate and Transport

Modeling was conducted for the ABRA (Holdren et al. 2002) to simulate release and migration of contaminants from waste buried in the SDA and to estimate future contaminant concentrations in environmental media. Models implemented were essentially the same as those used in the IRA with some improvements to incorporate additional data. Several sensitivity cases were modeled to evaluate effects of variations in several parameters of interest on estimated media concentrations and risk.

Complete exposure pathways defined by the conceptual site model formed the basis for three types of simulations: (1) source release, (2) subsurface transport, and (3) biotic transport. Persistence of contaminants in the environment was evaluated based on contaminant mobility controlled by dissolved-phase transport and biotic transfer by animals and plants intruding into the waste. For radioactive contaminants of potential concern, half-lives also were considered. Chemical degradation was not assessed.

The DUST-MS source-term model was used to simulate release of contaminants from waste and into the subsurface. Based on waste inventory estimates and waste characteristics, the model simulated the release of contaminant mass from buried waste for three types of release mechanisms: (1) surface wash off, (2) diffusion, and (3) dissolution. Once mass was released, it was available for biotic transport to the surface or for migration in the subsurface. Sample data for the shallow subsurface from areas around the SDA were not representative of concentrations beneath the waste and, therefore, were not useful for calibrating the source-term model. Indirect, limited calibration was achieved by comparing measured to simulated aquifer concentrations.

Subsurface fate and transport modeling focused on dissolved-phase transport using the TETRAD simulator. Vapor-phase transport was not specifically modeled for this investigation for contaminants such as C-14. For volatile organic compounds (VOCs), concentrations were estimated by scaling results in the IRA (Becker et al. 1998) on the basis of revised inventory estimates. Using information from the source release model, the TETRAD model simulated migration of dissolved-phase contaminants in the vadose zone and aquifer. The model emulated fate and transport beginning in 1952 and extending until concentrations peaked in the aquifer up to 10,000 years in the future. The model domain was based on interpolations of known characteristics of the subsurface, such as depths and thicknesses of interbeds and water velocity in the aquifer. Other model parameters to describe contaminant migration, such as partition coefficients, were defined using site-specific information. Reasonable values from the literature were selected when site-specific information was unavailable. Estimated media concentrations were compared to monitoring data. However, model calibration beyond limited calibration achieved previously in the IRA (Becker et al. 1998) was not attempted because of the lack of calibration targets provided by monitoring data. In other words, contaminants of particular interest for model calibration—such as C-14, uranium, and other actinides—have been detected sporadically and at very low concentrations that do not describe migration trends. Low concentrations, coupled with lack of trends, cannot be emulated with any confidence.

The DOSTOMAN code was used to simulate transport of contaminants to the surface by plants and animals and to estimate resulting surface soil concentrations. Rate constants and other input parameters used in the code were selected from current literature, with preference given to values specific to the SDA and the INEEL. Though limited comparisons of estimated-to-measured surface soil concentrations were produced, calibration for the biotic model was not pursued. Maintenance, contouring, and subsidence repairs at the landfill disturb the surface of the site, and the sparse data that are available are not representative of biotic uptake. In addition, the analysis adopts the fundamental assumption that future action at the SDA under any remediation scenario will include a cap that would inhibit human intrusion and biotic uptake.

1.3.5 Baseline Risk Assessment

Waste Area Group 7 was considered in a comprehensive manner in the ABRA (Holdren et al. 2002) by evaluating the cumulative, simultaneous risk for all complete exposure pathways for all contaminants of potential concern. The assessment evaluated impacts of exposure to concentrations of contaminants in soil and groundwater estimated by the models described in the preceding section. Estimated current and future impacts to human health and the environment are described below.

1.3.5.1 Human Health Baseline Risk Assessment. Potential risks to human receptors posed by the 24 contaminants of potential concern (COPCs) defined in the WAG 7 IRA (Becker et al. 1998) were quantitatively evaluated in the human health component of the ABRA (Holdren et al. 2002). Exposure and toxicity assessments, risk characterization, and limited evaluation of sensitivity and uncertainty were included. For radionuclides, long-lived decay chain products were considered to assess cumulative effects. Risks from VOCs were scaled from the IRA (Becker et al. 1998) results based on inventory updates.

Exposure scenarios were defined to assess hypothetical current and future occupational receptors and for current and future residential receptors. For the current residential scenario, groundwater ingestion risk at the INEEL boundary was assessed. Surface exposure pathways were not examined for a current residential exposure because residential development near the RWMC is prohibited by site access restrictions. Future residential exposures were simulated to begin in 2110 to reflect a postulated remediation in 2010 followed by an assumed 100-year institutional control period. The future residential analysis reflects assumptions that a cap and institutional controls would preclude access into the waste, but that a location immediately adjacent to the RWMC could be inhabited. Concentrations and risks were simulated out to 1,000 years for all pathways except groundwater ingestion. Groundwater risks were simulated until peak concentrations occurred up to a maximum of 10,000 years.

Risk estimates for a hypothetical, future, residential exposure scenario bounded risks for all scenarios because future residential risk estimates exceed estimates for both occupational scenarios and for the current residential scenario. Of 24 contaminants analyzed in the ABRA, 16 were defined as OU 7-13/14 contaminants of concern (COCs) based on estimated risk in excess of 1E-05 or cumulative hazard index greater than 2. The location of the maximum cumulative risk is near the southeast corner of the SDA, and the primary exposure pathway is groundwater ingestion. A summary of the COCs identified in the human health component of the baseline risk assessment is provided in Table 1-1. The table reflects results for a 1,000-year simulation period.

The future residential risk over time for radionuclides is illustrated in Figure 1-8. The figure reflects the simulated 100-year institutional control period; thus, the hypothetical receptor location changes in 2110 from the boundary of the INEEL to the edge of the SDA. Therefore, discontinuities in Figure 1-8 at 2110 are attributable to the change in location for the hypothetical receptor from the INEEL boundary to the edge of the SDA.

1.3.5.2 Ecological Risk Assessment. Scope of ecological risk assessment conducted in the ABRA (Holdren et al. 2002) was limited because of the fundamental assumption that the SDA will be covered with a cap under any remediation scenario. Current-year and 100-year scenarios were evaluated for representative receptors. Contaminant screening documented in the *Review of Waste Area Group 7 Ecological Contaminants of Potential Concern* (Hampton and Becker 2000) limited the evaluation to those contaminants with a maximum likelihood to pose unacceptable risk. Concentrations in surface soil and subsurface intervals were estimated with the DOSTOMAN biotic uptake model. Ecological COCs were identified based on a hazard quotient in excess of 1 for radionuclides and a hazard quotient of 10 or greater for nonradionuclides. Seven contaminants of concern, which may exceed these hazard quotients, were identified in the ecological risk assessment (see Table 1-2).

Plant uptake and burrowing by animals was not shown to increase current surface soil concentration levels above the screening levels during the next 100 years. However, the assessment identified current and ongoing risk resulting from the following: (1) toxic exposures for plants with roots reaching surface and subsurface contamination; (2) ingestion exposures for animals eating those plants; (3) external and inhalation exposures for burrowing animals that feed above ground; (4) external, inhalation, and ingestion exposures for below ground feeders; and (5) ingestion exposures for predators that prey on animals contaminated on the SDA. Identified ecological risks could be addressed by actions implemented to reduce human health risk. Installation of a cap with a biotic barrier would inhibit plant and animal intrusion into contaminated subsurface soil, protect ecological receptors from contaminants, and reduce human exposures by preventing biotic transport of contamination to the surface.

1.3.5.3 Conclusions. Contaminants of concern were identified initially based on human health and ecological risk estimates. Risk-based criteria for human health of 1E-05 risk and a cumulative hazard index in excess of 2 were applied. Sixteen human health contaminants of concern were identified. In addition, three plutonium isotopes were classified as special case contaminants of concern to acknowledge uncertainties about plutonium mobility in the environment and to reassure stakeholders that risk management decisions for the SDA will be fully protective. Seven ecological contaminants of concern were identified based on a hazard quotient in excess of 1 for radionuclides and a hazard quotient of 10 or greater for nonradionuclides.

Table 1-1. Human health contaminants of concern.

Contaminant	Note	Peak Risk	Year	Peak Hazard Index	Year	Primary 1,000-Year Exposure Pathway
Ac-227		3E-06	3010[a]	NA[b]	NA	Groundwater ingestion
Am-241	1,3	**3E-05**	2953	NA	NA	Soil ingestion, inhalation, external exposure, and crop ingestion
Am-243		4E-08	3010[a]	NA	NA	External exposure
C-14	1,4	**6E-04**	2278	NA	NA	Groundwater ingestion
Cl-36		6E-06	2110	NA	NA	Groundwater ingestion
Cs-137		5E-06	2110	NA	NA	External exposure
I-129	1,3	**6E-05**	2110	NA	NA	Groundwater ingestion
Nb-94	1,3	**8E-05**	3010[a]	NA	NA	External exposure
Np-237	1,4	**4E-04**	3010[a]	NA	NA	Groundwater ingestion
Pa-231		3E-06	3010[a]	NA	NA	Groundwater ingestion
Pb-210		5E-07	3010[a]	NA	NA	Soil and crop ingestion
Pu-238	2	**1E-09**	2286	NA	NA	Soil and crop ingestion
Pu-239	2	**2E-06**	3010[a]	NA	NA	Soil and crop ingestion
Pu-240	2	**2E-06**	3010[a]	NA	NA	Soil and crop ingestion
Ra-226		3E-06	3010[a]	NA	NA	External exposure
Sr-90	1,4	**1E-04**	2110	NA	NA	Crop ingestion
Tc[redacted]	1,4	**04**	2110	NA	NA	Groundwater ingestion and crop ingestion
Th-229		4E-07	3010[a]	NA	NA	Groundwater ingestion
Th-230		7E-07	3010[a]	NA	NA	Groundwater ingestion
Th-232		1E-09	3010[a]	NA	NA	Crop ingestion
U-233	1,3	**3E-05**	3010[a]	NA	NA	Groundwater ingestion
U-234	1,4	**2E-03**	3010[a]	NA	NA	Groundwater ingestion
U-235	1,4	**1E-04**	2662	NA	NA	Groundwater ingestion
U-236	1,4	**1E-04**	3010[a]	NA	NA	Groundwater ingestion
U-238	1,4	**3E-03**	3010[a]	NA	NA	Groundwater ingestion
Carbon tetrachloride	1,5	**2E-03**[c]	2105	**5E+01**[c]	2105	Inhalation and groundwater ingestion
Methylene chloride	1,3	**2E-05**[c]	185	1E-01[c]	2185	Groundwater ingestion
Nitrates	1,6	NA	NA	**1E+00**	2120	Groundwater ingestion
Tetrachloroethylene	1,6	NA	1952	**1E+00**[c]	2137	Groundwater ingestion and dermal exposure to contaminated water

Notes: For toxicological risk, the peak hazard index is given, and for carcinogenic probability, the peak risk is given.

1. **Green** = The contaminant is identified as a human health contaminant of concern based on carcinogenic risk greater than 1E-05 or a hazard index greater than or equal to 1 contributing to a cumulative hazard index greater than 2.

2. **Brown** = Plutonium isotopes are classified as special-case contaminants of concern to acknowledge uncertainties about plutonium mobility in the environment and to reassure stakeholders that risk management decisions for the SDA will be fully protective.

3. **Blue** = Carcinogenic risk is between 1E-05 and 1E-04.

4. **Red** = Carcinogenic risk is greater than 1E-04.

5. **Pink** = Toxicological (noncarcinogenic) hazard index is greater than or equal to 1.

a. The peak groundwater concentration does not occur before the end of the 1,000-year simulation period. Groundwater ingestion risks and hazard indices were simulated for the peak concentration occurring within 10,000 years and are not presented in this table.

b. NA = not applicable.

c. The risk estimates were produced by scaling results from the Interim Risk Assessment (Becker et al. 1998) based on inventory updates.

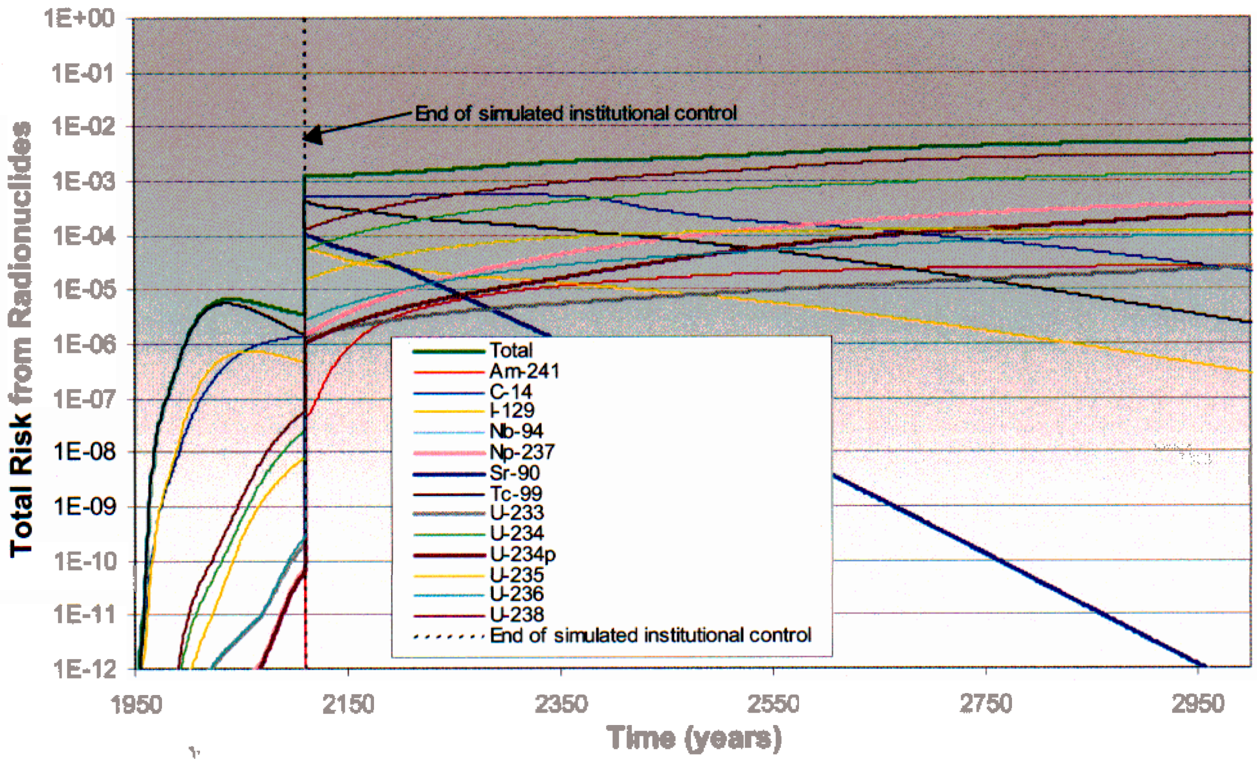

Figure 1-8. Hypothetical, future residential scenario cumulative risk estimates for radionuclides buried in the SDA.

Table 1-2. Ecological contaminants of concern.

Nonradionuclide Contaminant	Hazard Quotient[a] Current Scenario	Hazard Quotient[a] 100-year Scenario	Radionuclide Contaminant	Hazard Quotient[a,b] Current Scenario	Hazard Quotient[a,b] 100-year Scenario
Cadmium	<1 to <9	<1 to 20	Am-241	<0.1 to 21	0.7 to 41
Lead	<1 to <6	<1 to 20	Pu-239	NA	<0.1 to >1
Nitrate	<1 to >10	< 0.1	Pu-240	NA	<0.1 to >1
			Sr-90	<0.1 to >25	NA

NA— Concentrations for this contaminant did not exceed the ecologically based screening level. Therefore, it was not evaluated in the ecological assessment as a contaminant of potential concern for the given scenario.

a. The values reported represent the range of maximum hazard quotients calculated across receptor functional groups and species.

b. The range represents hazard quotients for both internal and external exposures.

Volatile organic compounds (i.e., carbon tetrachloride, methylene chloride, and tetrachloroethylene) and nitrates pose the most imminent risk. Nearly all of the volatile organic compounds and nitrates in the SDA originated at the RFP. Carbon tetrachloride has been detected in the aquifer slightly above the maximum contaminant level and is being extracted from the vadose zone to reduce risk. However, volatile organic compound release from waste buried in the SDA is ongoing and, if not sufficiently mitigated by the vadose zone vapor-vacuum extraction, poses the most imminent risk.

Mobile, long-lived fission and activation products are the next and most immediate concern. The majority of the mobile fission and activation products was generated by INEEL reactor operations. The degree of urgency associated with risk estimates for fission and activation products has not been validated because of uncertainties associated with C-14, I-129, and Tc-99 model parameters. Though these contaminants have been detected sporadically in the environment and some trends may be developing, they do not occur at levels predicted by the modeling. Monitoring locations immediately proximal to the waste using waste zone probes are extremely important to assess the rate at which potential contamination in the vadose zone is developing. Interpreting monitoring data can be used to validate the appropriateness of expedited remediation of buried waste to mitigate risk.

Uranium isotopes and Np-237 contribute the majority of the risk several hundred years in the future. Roughly half of the uranium inventories was generated at the INEEL, while the other half was generated off-Site, primarily at the RFP. Evaluating the nature and extent of uranium in the environment is confounded by naturally occurring concentrations of various isotopes in environmental media. Uranium attributable to human activities has been detected in the vadose zone beneath the SDA, indicating that some migration may be occurring. However, all local aquifer concentrations are consistent with natural uranium background values. Most of the original disposals of Np-237 originated at the INEEL, and nearly all of the Am-241 (the parent of Np-237) was generated at the RFP. Though Am-241 has been detected sporadically in the environment, Np-237 has not been detected.

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